Is Science under Siege?

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The cardinal attributes of science---discovery, innovation, rejection of dogma, exploration of frontiers---have been emblematic of our nation's character from the outset. Many of those who founded our country thought of themselves as scientists. And when the American Academy was established in 1780, it chose to include the sciences in its title.

Science has thrived here, and we have become the nation most advanced in virtually all fields of science and technology. As a nation of immigrants, we have attracted bright people who studied and stayed; even today, one quarter of the members of our National Academy of Sciences were born abroad. American scientists have been central to the discoveries of the 20th century that have transformed our understanding of the world, driven our economy, and radically altered and dramatically extended our lives---atoms and genes, new vaccines, medicines, and chemicals; airplanes, televisions, cell phones, lasers, computers, and pacemakers.

Mid-way through the 20th century, after science helped us win the Second World War with quinine, radar, and atomic bombs, our Federal government assumed responsibility for a massive expansion of research, especially basic research; the bargain may have had Faustian aspects, but the dividends have been handsome.

At the start of this new century, science continues to be exhilarating. In my own field of cancer research, these are extraordinary times. By learning the genetic damage that drives cells to become cancerous, we can classify cancers more accurately and, for a few important conditions, treat them more effectively. Our institution across the street (Memorial Sloan-Kettering

Cancer Center) is not alone in showing enthusiasm for science by expanding our research facilities, building new programs, and training more people to study these diseases.

From this perspective, it may seem surprising that we are gathered here tonight to worry about the scientific enterprise in America. But---despite the successes of the past century and despite the optimism about what science can achieve in the next---science seems to be under attack on several fronts. Scientists report anxiety about their career prospects and a sense of alienation from the dominant culture and politics of our society. Anxiety and alienation are not new to science, but they are perceived as more acute and more intense now than in recent memory, and driven by many things: by an under-appreciation of science as an essential feature of our culture, by declining budgets for science, and by sharpened conflicts with religion in education and science policy.

I have been asked to speak to you today about these anxieties---their causes, the objective reality, and some remedies. To do this, I must talk about topics on which I must confess not to be truly expert: political science, ethics, economics, history, and even theology. But I can give you a personal account of the concerns; I can try to categorize and analyze them as they are perceived by a working scientist; and I can make some judgments about their seriousness and reversibility.

It is no coincidence that these anxieties have arisen in this country at this time, in this Administration. Science addresses natural phenomena. But its method---testing ideas by evaluating evidence---is applicable to nearly all fields of thought. This Administration will be remembered, in large part, for a war in Iraq that was based on two hypotheses, both of which lacked evidentiary support: that Saddam Hussein's regime was linked to the terrorism that produced the attacks on America on 9/11, and that "weapons of mass destruction" existed in Iraq. Failures to apply the scientific method to issues of war and peace can be seen as harbingers of the respect the Administration has shown for science itself.

Why are scientists unhappy with the Bush Administration?

For many scientists and citizens, awareness of a pattern of disrespect for science began nearly two years ago, in February of 2004, when the Union of Concerned Scientists provided an itemized summary of the several actions

taken by the Bush Administration during its first term (http://www.ucsusa.org/scientific_integrity). (For those who don't know, the UCS is an organization of scientists and citizens, led by Kurt Gottfried, a Cornell physicist who is in the audience tonight, that mainly promotes scientific solutions to environmental problems.)

• Perversions of policy-making

The central theme emerging from the UCS report was a disregard for principles that have characterized the advisory role that the scientific community had served in virtually all Administrations, Republican or Democrat, for five decades: that is, the government seeks unadulterated opinions from a broad spectrum of scientists, evaluates those opinions as objectively as possible, and then makes policy in the context of political and economic contingencies.

As the UCS report documented, the Bush Administration has subjected potential advisors to inappropriate tests of political preference; edited scientific reports with prejudice before they were read by policy makers; limited the freedom of government scientists to voice their opinions on scientific questions that might have policy implications; appointed individuals with questionable expertise to advisory groups or to responsible posts in science agencies; and reduced the status of the Office of Science and Technology Policy within the White House.

These practices have changed the traditional interactions of science and government across a broad spectrum of topics of immense public concern---especially energy, climate, the environment, and health. Fortunately, the revelations have been widely reported in the press, and legislation intended to reduce some of the illegitimate practices has been proposed by Representative Henry Waxman, Senator Dick Durbin, and others and seems likely to pass if voted on.

But that is the good news. While the Administration did take note of the charges and sent the Science Advisor to offer a feeble defense, changes in behavior have been hard to discern. Indeed, there is reason for continued concern. Here's one telling vignette. For over a year, the Food and Drug Administration has continued to reject overwhelming recommendations by advisory groups for approval of the drug, called Plan B (technically, Levanorgestrel), as an over-the-counter agent that can prevent unwanted

pregnancies resulting from recent, unprotected sex. (As reported in yesterday's New York Times, the Government Accounting Office has now documented the irregularity of this decision-making process at the FDA.) The FDA Commissioner, Lester Crawford, whose confirmation this July was predicated on a promise of action on Plan B, unexpectedly resigned in September, without a credible explanation. Then the White House named the current Director of the National Cancer Institute to be the Acting FDA Commissioner, without requiring him to relinquish his position at the NCI. No single person should simultaneously oversee the workings of the FDA (which is responsible for one quarter of the US economy) and the NCI (which oversees one-fifth of the NIH budget). This situation creates conflicts of commitment and conflicts of interest, and it shows contempt for these agencies and their activities.

• Regressive policies

Scientists are concerned, of course, not just about how policies are made, but also with the policies themselves. Of the science policies espoused by this Administration, perhaps the ones best known to the public are those affecting climate change and the new world of human stem cell research. For those of us---scientists and citizens alike---who are impressed with the prospects for discoveries and, ultimately, beneficial changes in medical practice through such research, the present Federal rules are troubling and unduly restrictive. They have slowed the pace of progress here, given advantage to other countries (such as the United Kingdom), and discouraged young scientists from contemplating careers in this exciting new field. Even at the time, the decision announced by President Bush on August, 9, 2001, to limit Federal funding to work on human stem cells lines already in existence, seemed politically calculated, rather than scientifically or even ethically reasoned. Now that seems only more so.

Some of the consequences of his policy have been predictable. After all, the number of useful lines was never as large as claimed, has diminished with time, and never included lines that could be tested clinically.

Other consequences would have been difficult to anticipate. The most important, in the long run, may be the fragmentation of the nation's research effort. Rather than building a unified national program to pursue this new work, we are creating a patchwork quilt of state policies that range from prohibitions of work permissible elsewhere to state financing of work

ineligible for Federal dollars. California illustrates the latter extreme: voters strongly endorsed stem cell research by passing a bond measure that will provide $3 billion over ten years, if the multiple legal challenges to the initiative can be resolved. A few other places, including New York City, have benefited from private philanthropy for stem cell work. These pockets of affluence will inevitably and inequitably distort the distribution of stem cell investigators across the nation and these precedents could provide incentives to further fragment the historically successful Federal oversight and funding of medical research.

• Poor prospects for funding

These policy issues are important, but for most scientists in the trenches the most immediate and daily concern is financial support for their disciplines and the ability to attract bright trainees to work with them.

The United States still leads the nations in total support for science and it remains among the top few when science funding is measured as a fraction of the Gross National Product. But budget projections for science agencies are flat, without even inflationary increases, at a time when the promise of science and the need for science are unprecedented. Federal support for the physical sciences has been unchanged or declining for many years, with no improvements in sight. Funding for elementary particle physics, for example, has been in steady decline for several years, and leadership of a field that we once dominated is now at least shared with the European physicists who are hosting the Large Hadron Collider in Geneva, where the next major discoveries are likely to be made after it opens in 2007.

Even the NIH, with the biggest budget among the Federal science agencies, about $28 billion, is facing trouble. To its credit, the Bush Administration fulfilled its pledge to finish a five year doubling of the budget that began in the Clinton era. But for the past two years---and almost certainly, for the coming year as well---the NIH budget has been flat, without even an inflationary increase. With this progressive loss of purchasing power, fewer grants can be awarded, at a time when the number of active investigators has grown significantly. This means that the success rates for grant applicants will be low, as low as 10 to 20 percent, especially for new applicants, such as those who have finally taken faculty positions after many years of undergraduate, graduate and post-doctoral training. Such stiff competition produces poor or arbitrary decisions and demoralizes the frustrated

applicants and reviewers alike. It should also worry the public that paid for much of the training of new investigators and wants them to be working in the laboratory, not re-writing grant applications.

• Discouragement of trainees

Although many excellent students are training in the sciences in the US at present, the budget forecasts transmit a discouraging message to prospective trainees. For several years American undergraduates have been steering away from math and some of the physical sciences. And, as has been widely publicized (even in an op-ed in this morning's NY Times), foreign students who had taken their places have been applying to our graduate schools in smaller numbers for the past few years.

Thus far, I have described how science is supported and science policy is formulated. But there is another widespread and more profoundly troubling phenomenon affecting the climate for science in the country.

• Religion in the science classroom

No one in this audience can be oblivious to the efforts by components of the religious right, represented most prominently in recent months by the Discovery Institute, to undermine the teaching of evolution in high school science classes. Indeed, hardly a day goes by without a prominent article in our leading papers about one of the battlegrounds or about the resurgence of creationism masquerading under the pretentious name of "intelligent design" (or ID). For anyone who has not heard, proponents of ID try to discredit Darwinism by pointing to human eyes or bacterial flagella as examples of "irreducible complexity" that evolution can't fully explain, implying they must be the product of a supernatural force.

Those who defend the concept that religious ideas, such as ID, have no place in science classrooms took heart at least briefly last week. In Dover, PA, where efforts by the local school board to present ID in biology classes are being challenged in the courts, voters replaced their entire school board with new members pledged to keep science separate from religion.

But these battles are far from over. A ruling on the court case is not expected until January; new standards that weaken the teaching of evolution have been approved (but not yet implemented) in Kansas; other efforts to

undermine instruction in evolution, the governing principle for all of modern biology, are ongoing in many of our states; and polls by the Pew Trust indicate that as many as 38% of Americans would like to see creationism replace evolution, not just co-exist with it, in the high school curriculum.

Still, I have been encouraged by the excellent and frequent coverage of these developments in our leading newspapers and magazines; by the bold warnings by some of our university presidents, especially Shirley Tilghman of Princeton (http://www.mskcc.org/mskcc/html/57686.cfm and Hunter Rawlings of Cornell (http://www.cornell.edu/president/announcement_2005_1021.cfm); and by the actions of many scientists, religious leaders, and other citizens concerned about the erosion of First Amendment principles, who have joined organizations formed to defend those principles (http://www.defconamerica.org/).

Unfortunately, the President and the Senate Majority Leader, Bill Frist, have been "enablers" of the campaign for the teaching of ID by naively suggesting that all views on human origins should be heard in our classrooms. Is it possible that they do not understand what is at stake? Namely, one of the nation's founding principles, our system of public education, and the future of American science!

BBFE: Should we "Blame Bush For Everything"?

So, how do we account for the many troubling features of the landscape that I have just painted? Although it is tempting to ascribe everything that now threatens science to the current Administration, it is not correct to do so. Instead, in large part, he and his Administration have been the "enablers" of the long term objectives of others. And they have failed to respond effectively to a new world order.

Three themes will dominate my discussion of underlying causes of our woes: the uncertain and poorly guarded boundaries between religion and state; the failure to recognize science as a foundation of our social and economic well-being; and our ambivalent attitudes towards the rest of the world. Our long-term failure to give more attention to these themes is now coming back to haunt us in an era of flawed Federal leadership.

• Blurring of boundaries between religion and state

The boundaries between religion and state have become increasingly blurred for several years, to the point at which the growing political force of evangelical Christians, often known as the "religious right," is affecting science (stem cell policy), the teaching of science (intelligent design), and public health (opposition to Plan B, opposition to the use of condoms in HIV prevention strategies, and, coming soon, opposition to the use of human papilloma virus vaccines to prevent cervical cancer). In each of these public health categories, religious dogma is trumping life itself.

This Administration is more beholden than any in my memory to the influence of religion. Some of us are old enough to remember the concerns during the 1960 Presidential election that John F. Kennedy, a Roman Catholic, would answer to the Pope in Rome, not just to the American public. I wish we paid as much attention to the First Amendment today.

It is ironic that our country has become captive to a relatively narrow segment of the religious spectrum, at a time when the breadth of that spectrum has grown dramatically, particularly with increasing immigration from Asian countries. But we as citizens have been lax in our responsibility to the First Amendment, to insure the separation of religion and state. And we as scientists have not been adequately engaged in efforts to understand and explain the relationship between religion and science.

Any first step in those efforts is to describe science and religion as largely separate spheres of activity: science asking How, religion asking Why; science invoking Reason, religion invoking Faith; science depending on objective evidence from the natural world, religion depending on subjective feelings and thoughts. In general, seen in this way, as many have noted, they are compatible and even complementary. Such distinctions help to explain why creationism (or ID) should not be mentioned in science classrooms: it makes no testable predictions and is supported by no evidence. It is not science.

But we also need to acknowledge that science and religion can be in conflict---and have been throughout history---depending on the scientific realms and the religious precepts. Most areas of science do not confront religious teachings as directly as reproductive biology, evolutionary sciences, or cosmology can. And some religions are much less dogmatic

and prescriptive than others. Still, almost all who turn to religion for help are seeking explanations for the bad things that happen in our lives and asking for some sense of purpose.

But for many scientists I know, one of the ruling ideas that emerges from the study of the cosmos, evolution, and reproduction is that of chance. For us, chance happenings can seem as remarkable as a god's purposes. The idea that chance, over billions of years, could lead to our universe, our galaxy, our earth, life forms, the human species and, especially, the human brain, is, in itself, breath-taking. Jacques Monod, one of the founders of molecular biology, said it well: "....like the man who has just won a million, we still feel the strangeness of our condition." A God may be an intruder on this landscape.

Just as science and religion need to define their differences, they also need to seek common ground. It is often said that scientists need to show more tolerance of religion. Yes, but religious groups, especially those in the fundamentalist sector, need to show more tolerance of secular humanism---a creed common among scientists. Recent reports in the New York Times may be encouraging in this regard: some components of the religious right are collaborating with environmental activists to protect the earth against global warming, and others are working with public health advocates for more spending to combat disease in Africa.

Current worries about the possibilities of an impending epidemic of avian influenza, one as terrible as the epidemic of 1918, may offer another platform for an enlarged understanding. During his remarks about the influenza situation a couple of weeks ago, President Bush referred to the idea that "from time to time, changes in the influenza virus result in a new strain to which people have never been exposed. These new strains have the potential to sweep the globe...." This is pure Darwinism: natural variation and selection. The influenza virus may look like a complex machine, with its spiked globe and multiple chains of nucleic acid, but no one is arguing that it or its derivatives are the "irreducibly complex" products of intelligent design. When the stakes are high, almost everyone turns to real science for help. Let's take advantage of the nation's interest in this possibly-coming plague to teach evolution!

• Ignoring the importance of science to society

A second problem is one for which scientists have largely themselves to blame: we have failed to keep the public adequately apprised of the crucial links between science and the social and economic benefits enjoyed in the developed world. This failure is especially damaging in the current Administration, because of its economic policies, which are driven by a compulsion to cut taxes, thus reducing Federal revenues and creating budget deficits. Unfortunately, this imperative has been honored in a manner oblivious to mandatory expenses (an ill-conceived war and unanticipated natural disasters) and in a manner oblivious to the social and economic benefits of Federal investments in science, education, health care, and many other things. As our budget deficits mount, science budgets fall. Because the investments in science and technology are crucial to the economic health of the nation, producing well-documented returns of 130 to 150 percent, the current Administration is really less of a friend to American business than is commonly thought; its policies threaten our future productivity and competitive stature.

A report issued by the National Academies two weeks ago, by a committee chaired by Norman Augustine, in response to a Congressional request, portrays this situation vividly and outlines the unhappy consequences for our economy and our social well-being if we do not change course (http://www.nap.edu/books/0309100399/html).

The report is particularly critical of the low status accorded to science teachers in our elementary and high schools; of the erratic and largely declining investments we are making in basic science; and of our failure to recognize that industrial productivity depends on scientific proficiency and incentives for innovation. The authors---who are themselves captains of industry, presidents of universities, and prize-winning scientists---reflect the influence of Tom Friedman's new book, The Earth is Flat, emphasizing the competitive challenge that we now face from India, China, and other Asian nations where students excel in science and math, where governments recognize that their futures depend on a highly skilled work force, and where high technology businesses are growing rapidly.

In reading the report, I was reminded of an essay written several years ago by David Goodstein, a physicist at CalTech. Goodstein observed that we use the wrong metaphor to describe how we teach science to children in the US. We don't have a pipeline that all students flow through, with a subset emerging as working scientists at the end. Instead, we have a diamond

mine in which we prospect, even at very early stages, for the gems who can win Westinghouse (now Intel) Prizes and then go on to even greater glory after attending schools on scholarships. We have done well with this method, fostering innovation, making discoveries, winning Nobel Prizes, building great universities and industries, and accumulating national wealth. But at the same time we have ignored the need for that large pipeline of students with strong skills in computation and technology and knowledge of scientific principles. This is the method that also generates science-savvy citizens.

As the new report explains, we are now in danger of losing our position at the head of the global pack unless we make substantial investments to support the teaching and practice of science. But this news comes at a time when we lack the financial resources to respond to the report's expensive recommendations with anything other than a resigned shrug.

• Failing to use science for global good will

America's status in the world has changed. We are now a feared and unequaled military power, neither faced off against the Soviets nor joined in harmonious alliances. In the eyes of many peoples around the world, we have become both a despised invader and a vulnerable target for terrorism, not the benevolent promoter of democracy we may aspire to be. And, while we remain the world's industrial leader, we are now being challenged by rising productivity in Asia and a united Europe.

We cannot afford to respond to these conditions with xenophobia or isolationism. Initially, after 9/11, immigration procedures became tougher, even for students and visiting scientists. Although the INS has responded to complaints from the academic community and eased visa procurement, impressions are hard to erase. While the declines in applications from abroad are not large, they are indisputable and worrisome: students, especially from Asia, are shifting their sights, mainly to other English-speaking countries with strong science programs.

This is a loss for us, and a change in international reputation that we must work to restore. We may have squandered the sympathetic good-will that we enjoyed after 9/11. But, at only modest cost, we can use our scientific skills to re-establish our good character. There are many ways to do this---by helping to coordinate international surveillance against infectious

diseases, like influenza, SARS, and HIV; by increasing our investments in science done abroad, especially in poor countries and especially on topics that promise local benefit---medicine, agriculture, energy production, and environmental remediation; by promoting connectivity through the Internet and assuring that scientific reports are made readily accessible to all. The essential internationalism of science is a powerful force that we can and should harness: to defend against global epidemic diseases, to diminish threats to the world's climate and environment, and to improve the well-being of people who live in the developing world, while also reversing our declining reputation.

The Bush Administration has not been oblivious to all of these things. Some of the promises it has made to promote health in Africa have gone beyond what earlier administrations have pledged. But the good intentions of compassionate conservatism have been held hostage by budget deficits, restrictive policies influenced by the religious right, and disagreements with those who should be our partners.

Is science under siege?

So how should we answer my rhetorical title? Is science under siege? I am sorry to say: Yes and No. "Siege" is probably too strong. "Stress" or "duress" might be more appropriate words, although they might have attracted a smaller audience. And, of course, science has always been under suspicion or even attack from various quarters, sometimes even from liberal academics. So how do we judge our current position?

• Its strengths

First, it is important to acknowledge our continued strengths. There is still considerable Federal financing of science, and, unlike scientists in most other countries, we enjoy additional financing from industry and from philanthropy to our academic institutions. The science done here is still outstanding, and the US remains the leader in most areas. In general, the public has confidence in science and scientists, especially in moments of crisis, even though large parts of it are ill-informed about science and misguided about how we should teach it. No significant exodus of our scientists has occurred, and we continue to attract many excellent students from abroad, albeit in declining numbers.

• Its vulnerabilities

But it is equally important to recognize other troubling features of the landscape: the fragility of the scientific enterprise, the importance of even subtle shifts in the research environment, and the difficulty of reversing downward trends. Furthermore, it is expensive and takes time to improve our teaching of science; politically difficult to confront the growing influence of the religious right; and hard to get the attention of a public distracted by terrorism, the war in Iraq, and many economic worries to explain the importance of science to the nation's future.

• Its hopes

But my own anxieties are tinged with optimism. I have mentioned examples of university leaders, scientists, clergy, and politicians who have boldly spoken up to defend the First Amendment, evolution in science curricula, the integrity of science policy-making, and many other things. In some states, the public is ahead of government leaders in appreciating the value of science, especially in controversial areas, such as stem cell research and climate change. Science journalism has improved in the past few decades, and generally presents our issues fairly.

Portrayals of science in the arts have blossomed on the stage (Copenhagen, Wit, Proof, QED), occasionally in the movies, and even this year in opera (Dr. Atomic); the Sloan Foundation and others are encouraging more of this. Our own American Museum of Natural History is opening its new Darwin exhibit on Saturday and holding public discussions of evolution. And effective popularizers of science, like Brian Greene, a cosmologist at Columbia, are proposing International Science Festivals in our cities, simulating events that have been successful in Europe. All of us can and should become cheerleaders for science

Two final, hopeful notes. You have all stayed around this evening to think with me about this situation; thank you. And, although 2008 may seem far off, there will be another Presidential election.